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Single Sideband Mixer

The invention concerns a single sideband mixer for high frequency signals. Such mixers are used in high frequency technology to generate a lower frequency signal (intermediate frequency, IF) from a higher frequency signal (radial frequency, RF) (down-converter or demodulator) or to generate a higher frequency signal from a lower frequency signal (up-converter or modulator). The IF signal is produced in the down-converter by mixing of the RF signal with the LO signal (local oscillator, LO). The RF signal is produced in the up-converter by mixing of the IF signal with the LO signal. Simple multiplication of an input signal (RF or IF) with the LO signal produces output signals with two sidebands shifted into the IF or RF range. A single sideband mixer produces only one of these two sidebands in the output signal. It is produced by appropriate connection of two individual double sideband mixers, hereinafter referred to simply as mixers. Their function can be understood as a multiplication of their two input signals.

Single sideband mixers for high frequency signals are known, comprising two mixers, each of which is wired with identical first signals and with second signals phase-shifted by 90° relative to each other, in order to form a product signal from the two signals, and an adder element to superimpose the two product signals to an output signal with only one sideband. A typical such demodulator is shown in Fig. 3. The RF signal here is fed from an input 4 via one or more amplifiers 1 and a 0° power divider, for example, a so-called Wilkinson divider, to two mixers 3. A 90° coupler 6 connected to a local oscillator input 5 delivers local oscillator signals, each phase-shifted by 90°, to the corresponding inputs of mixer 3. Intermediate frequency signals, phase-shifted by 90°, with both sidebands are obtained at the outputs of the mixer because of this. These are referred to as in-phase (IF/I) or quadrature-phase signals (IF/Q). These two intermediate frequency signals are combined or superimposed via a second 90° coupler 7 and produce the output intermediate frequency signal. Owing to phase-shifted feed of the local

oscillator signal to the two mixers, an in-phase and anti-phase signal are superimposed by the two sidebands of the in-phase branch and the quadrature branch behind the second 90° coupler 7. Two output signals, each of which contains only one of the two sidebands, are obtained at the two output terminals of the second 90° coupler 7. One of these terminals forms an output terminal 8 of the single sideband mixer; the other output is terminated with the wave impedance, in order to suppress interference signals and noise at the location of the undesired sideband (image frequency).

The power divider 2 of this ordinary single sideband mixer is required in order to decouple the in-phase branch and the quadrature branch of the single sideband mixer, i.e., to prevent the two mixers 3 from mutually influencing each other via their RF inputs. This type of power divider 2 includes coupled lines with a length of $\lambda/4$, in which λ is the wavelength of the radio frequency in the line. At technically relevant frequencies, this length corresponds to at least 1 mm. The power divider is therefore a very extensive part in comparison with the other components of the circuit, which is only poorly suited, for cost reasons, for integration on a common semiconductor substrate, together with the amplifiers, mixers or other components of the single sideband mixer. It is therefore used in the form of a discrete component, whose output terminals are connected to the conductor tracks leading to the mixers 3 via bond wires. To obtain good suppression of the undesired sideband at the output of the single sideband mixer, the signal travel times in the two branches must be adjusted to each other with micrometer accuracy, in order to guarantee that the product signals of the two mixers arrive at the second 90° couple 7 in the proper phase position. This can only be guaranteed with difficulty with the wire bonding technique.

Advantages of the Invention

A single sideband mixer for high frequency signals of the type defined at the outset is devised by the invention, which is readily suited for complete integration on a semiconductor substrate. This advantage is achieved in that an amplifier is connected upline of each mixer, and that these amplifiers have inputs connected to the same signal source via a forked line. The blocking power divider can drop out in this circuit topology, since the amplifiers already guarantee

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sufficient decoupling of two branches of the single sideband mixer, in which they block out interference signals issued by the mixers at their input line.

The signal source from which the amplifiers receive their input signal can be a common preamplifier connected at one input. In this case, the first signal is preferably an RF signal and the second signal a LO signal, and a first 90° coupler to generate the second signal is connected to an LO input of the signal sideband mixer.

The signal source can also be a signal input of the single sideband mixer. In this case, for example, the first signal can be a LO signal and the second signal an IF signal, and a first 90° coupler to generate the second signals is connected to an IF input of the sideband mixer.

Additional features and advantages of the invention are apparent from the following description, with reference to the figures.

In the figures

Figure 1 shows a down-converter as first practical example of the invention;

Figure 2 shows an up-converter as second practical example; and

Figure 3, which was already described above, shows an ordinary single sideband mixer.

The down-converter depicted in Figure 1 is fully integrated on a semiconductor substrate made of gallium arsenide. It includes a preamplifier 9 connected to a radio frequency (RF) input 4, whose output is connected via a single forked line 11 to two amplifiers 1, each of which pertain to an in-phase branch and quadrature branch of the single sideband mixer. These amplifiers 1 are based on fast field effect transistors, whose space requirements, on a semiconductor substrate at about 100 × 200 μm, are much smaller than those of a power divider. Since the amplifiers and preamplifiers are integrated on a common substrate, bond connections drop out, so that the line lengths between the preamplifier 9 and amplifiers 1, on the one hand, and between the amplifiers

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1 and the mixers 3 connected to their outputs can be stipulated with an accuracy of a few micrometers without difficulty during production. Although the in-phase and quadrature branch of the single sideband mixer each contain one more component than in the ordinary single sideband mixer, it is simpler in the single sideband mixer according to Figure 1 to maintain a desired phase ratio between the signals on the two branches during production.

The mixers 3 connected to the outputs of amplifier 1 also have an input for a local oscillator signal, which they obtain, each phase-shifted by 90°, from a 90° phase coupler 6, to which the local oscillator signal is again fed via an input 5 from the outside. A second input of coupler 6 is terminated with the wave impedance.

The two mixers 3 each deliver an in-phase or quadrature intermediate frequency signal to the inputs of the second 90° coupler 7, one output of which forms the intermediate frequency output of the single sideband mixer, and a second output is terminated with the wave impedance.

The 90° couplers 6 and 7 can each be integrated on the gallium arsenide substrate as hybrid elements.

Figure 2 shows application of the principle of the present invention to an up-converter. This single sideband mixer is also integrated on a single semiconductor substrate. The inputs of the two amplifiers 1 are connected via a simple forked line 11 to an input 5 for a local oscillator signal.

The intermediate frequency signal to be mixed with the local oscillator is fed from an input 4 via a 90° coupler 6 to the two mixers 4, each phase-shifted by 90°. The two mixers 3 generate radio frequency signals with two sidebands from it. These radio frequency signals with two sidebands are again fed to a 90° mixer 7, which superimposes them to two radio frequency signals, each with one sideband, that are delivered at the outputs 8A, 8B.

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The use of two amplifiers 1 in this up-converter also permits a power divider to be dispensed with and therefore integration of the entire single sideband mixer on a single semiconductor substrate.

The linearity of the RF path to the mixer outputs is improved by additional amplifiers 10 in front of the 90° coupler 7.

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